2017

Socioeconomic factors' effect on the maintenance of asthma: a chronic pulmonary disease

BOSTON UNIVERSITY

SCHOOL OF MEDICINE

Thesis

SOCIOECONOMIC FACTORS' EFFECT ON THE MAINTENANCE OF ASTHMA: A CHRONIC PULMONARY DISEASE

by

ANGELEQUE S. HARTT

B.S., Bates College, 2014

Submitted in partial fulfillment of the

requirements for the degree of

Master of Science

2017

Approved by

First Reader _____

Isabel M. Dominguez, Ph.D.
Assistant Professor of Hematology-Oncology

Second Reader _____

Suzy Ort, Ph.D.
Assistant Principal of Park East High School

ACKNOWLEDGMENTS

To My Wonderful Mother,

You have been my number one supporter throughout all of my endeavors. The amount of love and encouragement you have showered me with is something I would never be able to fully repay you for. Thank you for all that you currently do and have done for me in the past.

To My Creative & Inspirational Friends & Family,

Thank you for inspiring me to be the best that I can be and for being my support system throughout my academic career.

To My Peers,

Remember, "*smooth seas do not produce skilled sailors…"*

SOCIOECONOMIC FACTORS' EFFECT ON THE MAINTENANCE OF ASTHMA: A CHRONIC PULMONARY DISEASE

ANGELEQUE S. HARTT

ABSTRACT

Asthma is a chronic lung inflammatory disease that causes inflammation and narrowing of the airways. Swelling of the airways can be caused by the activation of cytokines that lead to an inflammatory or allergenic-like response. Environmental factors, both indoors and outdoors, have been found to increase the likelihood of asthma in children. Among those found to impact disease are air pollutants such as ozone, nitric dioxide, and particulate matter, as well as home exposures, like cockroaches and rodents. Those who have multiple or increased exposure to these pollutants are more likely to experience exacerbated symptoms and uncontrolled asthma. There currently is no cure for asthma, but effective therapies have been found to treat the symptoms associated with asthmatic episodes. During an asthma attack, due to narrowing of the airways, individuals experience wheezing, chest tightness, and even shortness of breath. To combat these occurrences, physicians use inhaled corticosteroids (ICS), Beta-agonist, or a combination of both to relieve symptoms.

In the United States asthma affects 25.8 million people. This number is projected to increase as the US continuously becomes more industrialized and as environmental conditions deteriorate. Research conducted by the Center for Disease Control concluded

that the prevalence of asthma increased amongst the general population, however, once the data were disaggregated by race, age, gender, and SES significant increases were noted amongst some groups but not others. Most notably, on average, children, women, Puerto Ricans, and people living in poverty as defined by federal guidelines had the highest asthma prevalence.

Chronic diseases like asthma also produce substantial burdens on the healthcare system. Asthmatics on average require three-times as many prescriptions, twice as many emergency room visits and four-times as many hospitalizations as individuals without asthma in the same demographic population.[9] Additionally, when an expenditure analysis was carried out, it revealed that children with asthma cost approximately three-times more per capita per child than adolescents without asthma.[9] Chronic disease occurs over the duration of individual lives. Thus, poorly managed, they will cause preventable increases in disability-adjusted-life years, premature death, and health care expenditure for both the individual and the broader healthcare system. The observed increases will predominantly impact the indicated high-risk populations.

The prevalence of asthma in urban settings was anticipated by researchers based on known environmental influences. However, the discovery of a higher prevalence and mortality rate of asthma within impoverished communities, in comparison to other urban communities, is not yet fully understood. Through this research an association between high-risk populations with uncontrolled asthma and a lack of patient education, low

socioeconomic status, and utilization of Medicaid insurance was found, which indicates the influence of these factors on asthma control. Improving current asthma interventions by remodeling them to take a broader stance on asthma prevention, treatment and maintenance and through acknowledgement of the impact disparities, asthma will likely be better controlled for all individuals in the Unites States.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

BMC ..... Boston Medical Center

BU ..... Boston University

CDC ..... Center for Disease Control

DALYs ..... Disability-adjusted-life-years

ED ..... Emergency Department

GAPPS ..... Global Asthma Patient and Physician Survey

ICS ..... Inhaled Corticosteroid

JAMA ..... The Journal of the American Medical Association

LABA ..... Long Acting β-Agonists

NCHS ..... National Center for Health Statistics

NHLBI ..... National Heart, Lung, and Blood Institute

NIH ..... National Institute of Health

NO_2 ..... Nitric Dioxide

PCP ..... Primary Care Physician

PM ..... Particulate Matter

SABA ..... Short acting β-Agonists

US ..... United States

WHO ..... World Health Organization

INTRODUCTION

Asthma is a chronic lung disease that causes inflammation and narrowing of the airways[1]. An asthmatic episode is characterized by one or a combination of wheezing, chest tightness, shortness of breath, and coughing[2]. Inflammation of the airways can be caused by the activation of cytokines that lead to an inflammatory or allergenic-like response. The specific type of cytokines activated is dependent on the type of mediator that binds[3]. In a normal functioning lung, there are defense barriers in place to prevent pathogens and foreign particles from permeating the lining of the respiratory tract or entering the alveoli. However, in asthmatic patients, these mechanisms are usually defective[3]. Both environmental and genetic factors have been correlated with asthma, yet environmental factors have been more extensively researched and agreed upon by the literature. The high prevalence of asthma discovered in urban settings was anticipated by researchers based on known environmental influences[4]. However, the discovery of higher prevalence and mortality of asthma in communities of low social economic status in comparison to other urban area communities, is not yet fully understood[4].

Anatomy of the Lungs and Intrinsic Defense Mechanism

The lungs are a pair of organs that sit in the thoracic cavity and surround the heart. Each lung is covered by a double-layered pleura that supports its primary role of gas exchange[5]. The lungs are connected to the nasal and oral cavity, in which gas enters the body via the trachea and bronchi. The characteristics of the latter structures provide

initial protection to the respiratory system. The nasal cavity, composed of a mucous membrane and cilia, moisten, filters, and warms inhaled air. Under normal conditions, bacteria, dirt, and chemical particle of significant size that enter the cavity are entrapped in the mucus, whereas those that manage to bypass this defense, are directed towards the back of the throat in hopes of being killed by the digestive system[5]. The trachea and bronchi are divided into conducting and respiratory zones, where the conducting zone provides another key defense known as the mucociliary escalator. This mechanism utilizes the action of cilia located in the respiratory epithelium to push dust and particles towards the oral cavity to be expelled[5]. Defects in these two mechanisms are commonly found in individuals diagnosed with asthma.

Environmental Factors Associated with Asthma

Environmental factors, both indoors and outdoors, have been found to increase the likelihood of asthma in children. Among those found include air pollutants ozone, nitric dioxide, and particulate matter, as well as home exposures, like cockroaches and rodents[6]. These factors have been shown to elicit an asthmatic episode by triggering the production of reactive cytokines, weakening the respiratory defense barriers, or a combination of both[3].

Outdoors, ozone is the main component in “summer smog” present in many cities[3]. It is generated by photochemical reactions involving ultraviolet radiation on

atmospheric mixtures[3]. Inhaled ozone, as well as NO_2, has been found to cause deterioration of lung function via the breakdown of the mucociliary escalator and increased airway reactivity towards specific and non-specific antigens[6]. Ozone also causes an increase in the release of inflammatory agents that trigger bronchoconstriction. Nitric dioxide is also found in air pollution and can lead to the formation of ozone. However, the most abundant concentrations of NO_2 are found indoors due to the use of gas stoves and space heaters[3]. Lastly, particulate matter is considered to be the most serious pollutant, as it has been linked to many diseases which impact health[3]. PM is a mixture of solid and liquid particles that differ in size and composition, which has a unique mechanism of causing asthma, as it does not directly cause the weakening of defense mechanisms. Due to the variations in its composition, PM can evade defense mechanisms and penetrate the airways to induce airway inflammation[6].

Indoors, the presence of specific organisms has been linked to the exacerbation of asthma symptoms. Cockroaches and rodents are recognized as factors that cause asthma as asthmatics were found to be highly sensitized to their allergens.[6] Specifically, it was found that the prevalence of infestations with these organisms were found to be higher in low socioeconomic areas in urban settings[6]. One or a combination of these factors have shown to increase asthma related symptoms and severity[3]. The Urban Environment and Childhood Asthma (URECA) study was an observational prospective analysis of the association between the development childhood asthma and urban inner-city environments conducted in Baltimore, Boston, New York City and St. Louis.[7] This study

followed a total of 609 newborns (560 newborns from families with a high risk of asthma and 49 newborns from asymptomatic families) from birth until 7 years of age to assess for any abnormal respiratory development. [7] This study, which was comprised primarily of African-American and Hispanic women of low socioeconomic status, showed a recurrent wheeze at 3 years of age and the development of asthma by the age of 7.[7]

Asthma Burden on the US Healthcare System

In 1989 the Global Initiative for Asthma (GINA) program was started to raise awareness around the increase in prevalence of asthma.[8] Currently, in the United States this chronic ailment affects 25.8 million people and is projected to continuously increase as this and extended nations become more urbanized. However, since this prevalence was calculated based on conservative criteria, the true value is expected to be significantly higher.[9] The Center for Disease Control (CDC) conducted a report to assess the prevalence, health resources used and mortality rate associated asthma in the US between 2001 and 2010. Through this analytical time period, the prevalence of asthma increased steadily amongst the general population, however, once the data was stratified for race, age, gender, and SES substantial increases were noted amongst distinct groups. Most notably, on average, children, females, Puerto Ricans, and low socioeconomic communities were found to have the highest prevalence of asthma (Figure 1).[9] These characteristics are not unique to the US as the trend of chronic illnesses continues to disproportionately affect those living in poverty around the world.[8]

Lastly, it was found that although the prevalence rate of asthma continued to climb during the study period, the overall mortality rate of the population steadily declined, while hospitalizations, ED visits and outpatient visits in relation to asthma remained steady. This indicates that currently available treatments were effective at subsiding the acute symptoms of an asthmatic episode but not managing the disease burden on the population (Figure 2).

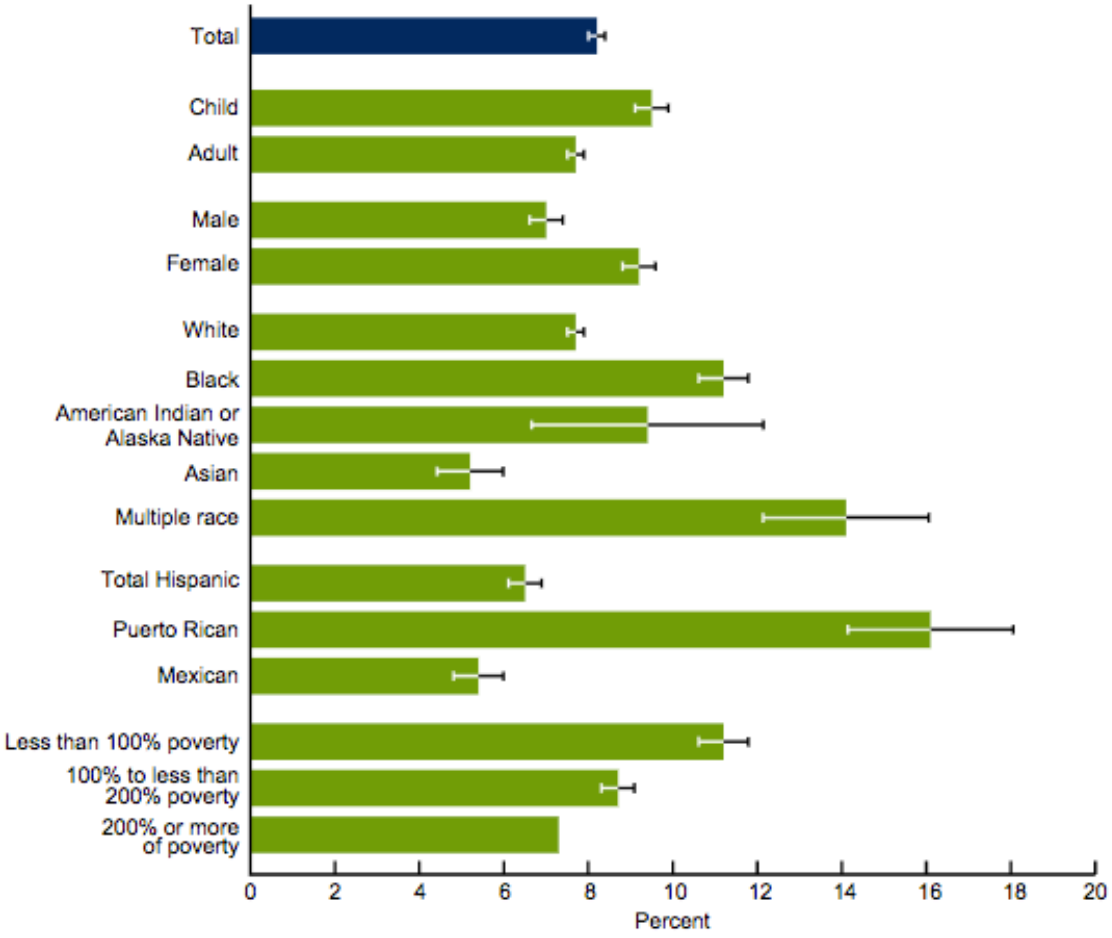

Figure 1. Prevalence of asthma based on age, sex, race, and SES within the US[9]

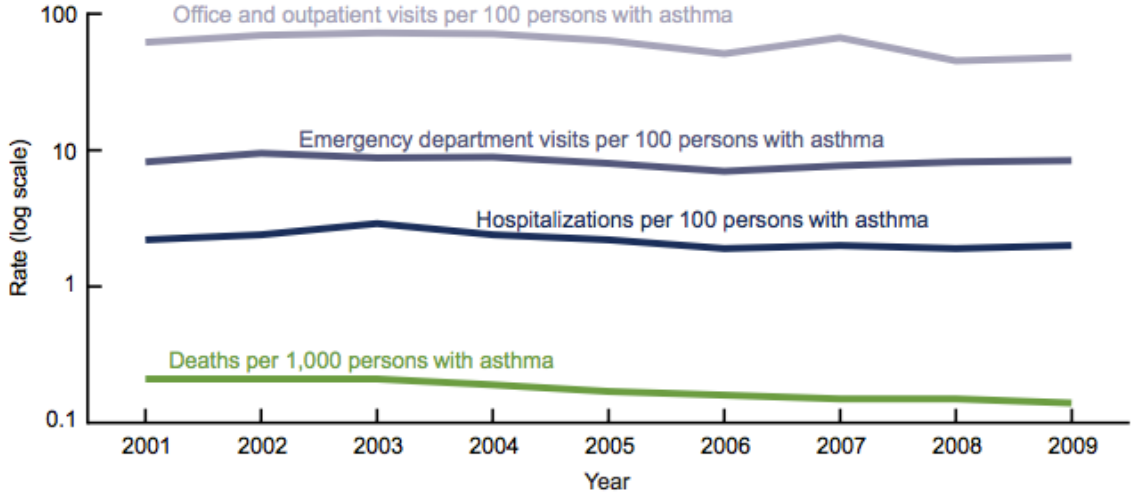

Figure 2. Health care encounters per 100 persons with Asthma and Asthma related deaths per 1,000 persons.[9]

A comparative study conducted by Lozano et. al analyzing the per capita cost of adolescent medical care for asthmatic and non-asthmatic individuals in the US was used to depict the burden of asthma on the US healthcare system. As indicated in the findings of this study, adolescents with asthma required three times as many prescriptions, twice as many emergency department (ED) visits and four times as many hospitalizations as individuals without asthma in the same demographic population.[9] Additionally, when asthma care alone was compared to that of all medical care for non-asthmatic children, the utilization rates were equal (Table 1). Furthermore, when a cost analysis was carried out, it revealed that children with asthma cost approximately three times more per capita per child than adolescents without asthma[9] (Figure 3). Collectively, as indicated by this study, chronic diseases like asthma place a substantial resource and economic burden on the US healthcare system.

Table 1. Comparison of healthcare utilization by US children with and without asthma[9]

	Prescriptions (mean [SD])	ED visits (mean [SD])	Hospitalizations (mean [SD])
Children without asthma			
Total: age 1-17 y (n = 7578)			
All care	1.6 (2.9)	0.22 (0.61)	0.04 (0.24)
Children with asthma			
Total: age 1-17 y (n = 667)			
All care	4.9 (6.9)	0.48 (1.01)	0.14 (0.53)
Asthma care	2.0 (4.8)	0.12 (0.58)	0.04 (0.25)
Age 1-4 y (n = 201)			
All care	6.1 (6.2)	0.79 (1.32)	0.27 (0.77)
Asthma care	1.8 (3.6)	0.15 (0.54)	0.08 (0.38)
Age 5-9 y (n = 163)			
All care	4.8 (7.2)	0.34 (0.74)	0.06 (0.26)
Asthma care	2.1 (4.6)	0.12 (0.57)	0.01 (0.10)
Age 10-17 y (n = 303)			
All care	4.2 (7.1)	0.36 (0.85)	0.08 (0.41)
Asthma care	2.1 (5.4)	0.10 (0.61)	0.02 (0.18)

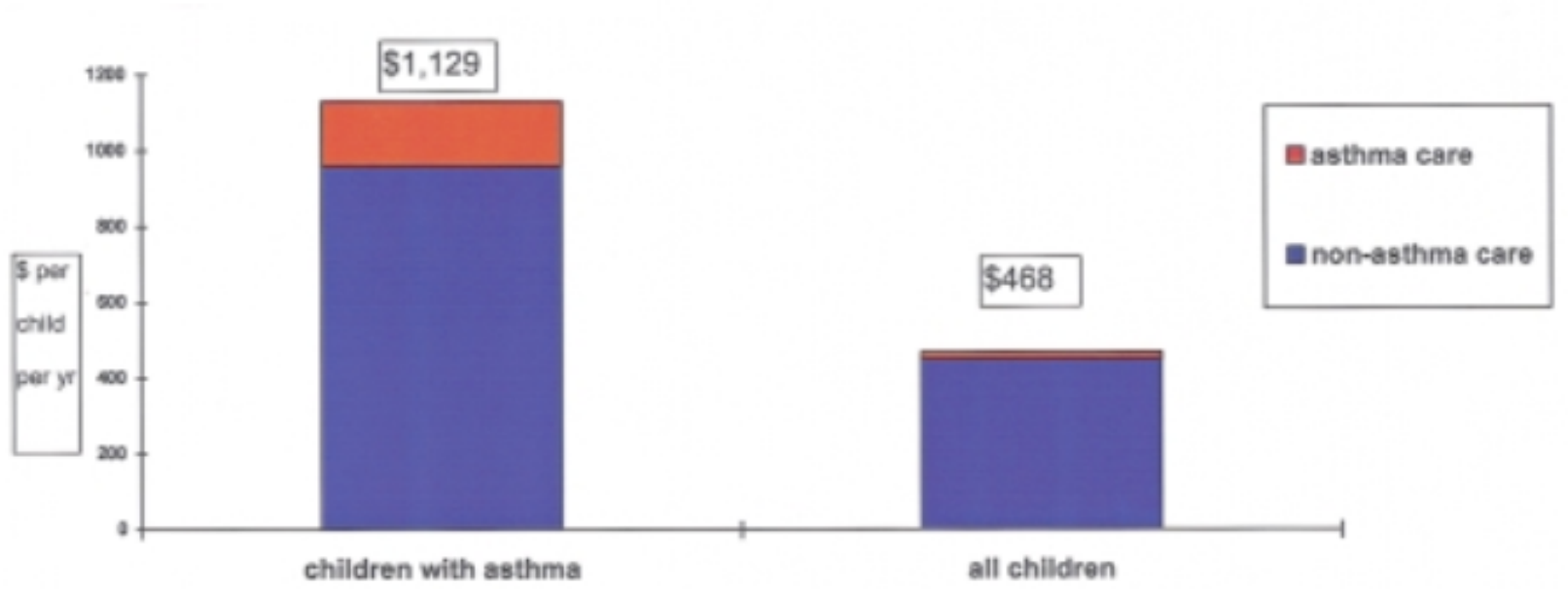

Figure 3. Health care expenditure per child per year for children with and without asthma in the US.

Asthma Treatments

There is no cure for asthma, however many effective treatments oriented at symptom management, have been discovered. As previously discussed, when an asthmatic episode is triggered, bronchi inflammation occurs, and leads to the constriction of airways. The types of current treatments targeted at reducing inflammation are categorized into two categories - quick relief and long lasting medications. Although therapies that fall into either category can be used on their own, the current recommended treatment is that of combination therapy[10]. These include inhaled corticosteroids (ICS), which are considered to be the most effective, Short acting β-agonists (SABAs), long acting β-agonists (LABAs), and Leukotriene receptor antagonists[10] (Figure 4).

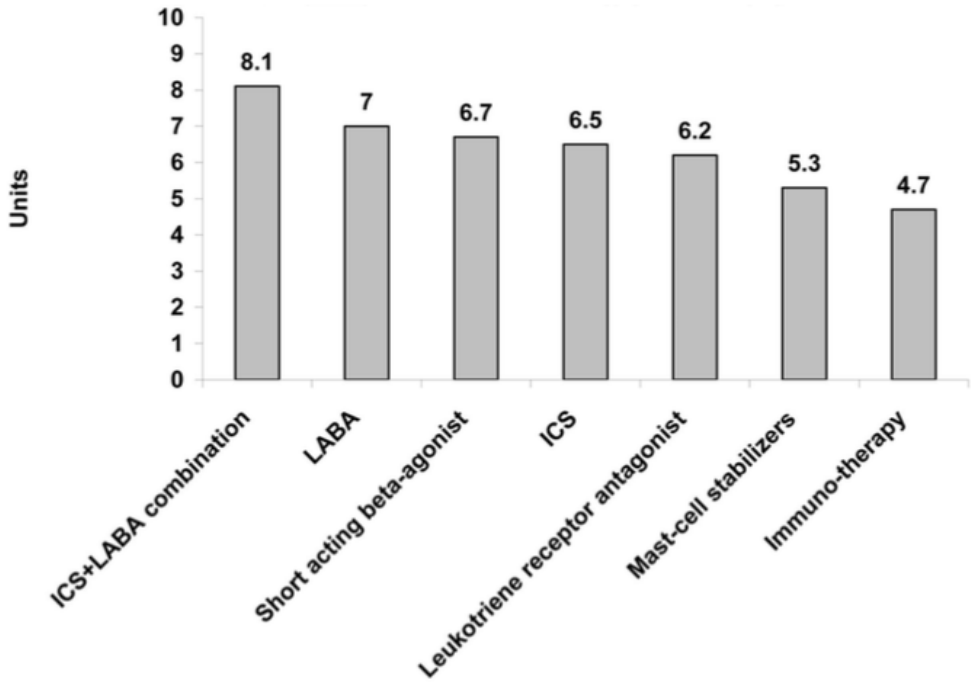

Figure 4. Average Physician satisfaction with currently available Asthma Treatments; 1= least satisfied, 10= most satisfied[10]

Although combination therapy of ICS and LABA is considered to be the most effective, its utilization presents with poor adherence and suboptimal therapeutic outcomes. A major cause of these observations is thought to be noncompliance with treatment[10]. As shown in Figure 5, the primary reason patients gave up or switched medications was "Symptoms went away or lessened" and the third being "medication was too expensive".[10]

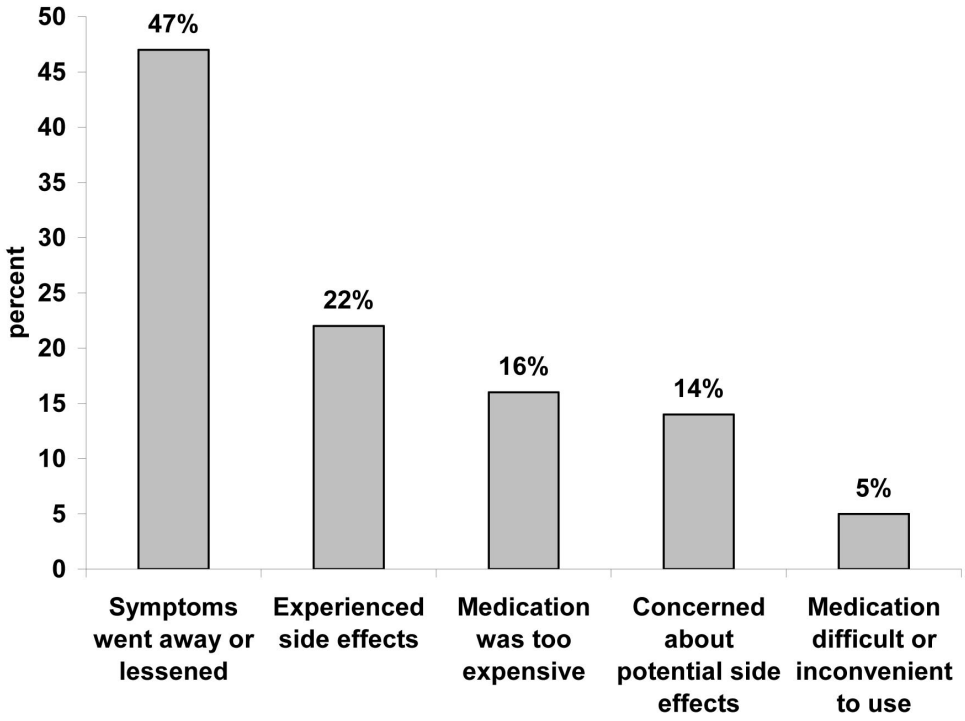

Figure 5. Factors associated treatment noncompliance[10].

As indicated previously, the prevalence of asthma is higher in urban settings, more specifically in low socioeconomic communities despite the availability of effective treatments. Specific socioeconomic factors, other than increased environmental hazards, have not been adequately explained to account for this trend.

Standardized Methods of Asthma Control in the US

The US health system, like many other health systems in the world, is predominately comprised of vertical programs that are geared towards the prevention and treatment of a pathological disease without consideration for comorbidities that contribute to the diseased state. With use of the aforementioned medical treatments, a routine procedure implemented and followed by physicians focuses on subsiding the presenting symptoms associated with an asthmatic episode.[11] According to Higgins et. al, the conventional management of acute asthma is to relieve bronchospasms, improve gas exchange through opening of the airways, and treat the underlying cause.[11]

Although decades of research have led to the development an effective procedure for when patients are experiencing acute symptoms, patient education and asthma action plans to prevent future attacks were often not included. This finding is significant as it further supports the need for horizontal programs which target not only the pathology of disease but also additional factors associated with the ailment. By taking a broader approach towards prevention, treatment and management of chronic diseases it can be expected to observe a decrease in prevalence across all demographics in the population.

SPECIFIC AIMS AND OBJECTIVES

The specific aim of this literature based thesis is to assess the multiple socioeconomic factors on the control of asthma symptoms. As shown in the literature, extensive research has been done on environmental factors associated with the prevalence of asthma, including those associated with communities of low socioeconomic status. However, disparities in relation to medical insurance, socioeconomic status, and patient education within these specific communities also may play a role in the prevalence and lack of control of asthma. Assessing the causes for the lack of reduction in chronic diseases, such as asthma, within communities of low socioeconomic status is essential since these illnesses account for approximately 60% of deaths worldwide and disproportionately affect these communities.[12] This topic is of interest, specifically because although it focuses on inner cities within the US, the disparities highlighted and potential solutions discussed can be applied to similar regions around the world.

Asthma as a chronic condition and its associated medical treatment is not a new phenomenon within the field of health as the first case documented case of asthma occurred in 460-357 BC by Hippocrates.[13] Despite an abundance of research surrounding asthma, its biological and environmental causes, as well as its increase in prevalence within inner city neighborhoods, the potential impact of social and economic disadvantages on the high burden of disease has traditionally been overlooked.

Uncontrolled asthma results in a higher use of health benefits and an increase in an avoidable burden placed on the health system. However, in order for asthma to be controlled, access to quality care is essential. Disparities in urban areas often produce a barrier for individuals to receive properly tailored care for this chronic condition. While guidelines exist indicating ways to manage asthma, it is vital that the method used is appropriate for the population which is being served.[14]

The goal of this paper is to show the existence of factors other than environmental pollutants, such as socioeconomic status, level of education, and the strength of doctor-patient relationships (education of disease), that contribute to the high prevalence of asthma in high-risk populations. Through completion of this analysis, it is hoped that medical treatment and proposed interventions for asthma prevention and reduction can be redesigned to account for all influencing factors.

PUBLISHED STUDIES

PubMed, Science Direct, and Google Scholar were used to search for articles pertaining to asthma, its maintenance, treatments and interventions, and burden on high-risk populations within the United States. The applicable articles used in this research were summarized and condensed in an effort to provide supporting evidence for future improvements in asthma maintenance.

The Global Asthma Physician and Patient (GAPP) Survey

The Global Asthma Physician and Patient (GAPP) Survey is a quantitative study conducted across 16 countries aimed at evaluating the perceptions of both physicians and patients on asthma treatment and management, education pertaining to symptoms of an asthmatic episode, and lastly, the side effects and consequences of medication nonadherance.[10] In the US 208 adults over the age of 18 with a physician-diagnosed case of asthma and 224 physicians who treat 3 or more patients with asthma per week were recruited into the study.[10] Data was collected using a self-administered online questionnaire formatted with close-ended questions regarding patient and physician perceptions of the patient's general asthma education, the frequency of discussion regarding short and long-term side effects of asthma medications, and the consequences of noncompliance with asthma medications.

A patient can be concluded to have adequate asthma education if he or she can dictate what asthma is, its symptoms, generally what causes an asthmatic episode, their

treatment plan, and proper usage of inhaler techniques. In a standard fiduciary doctor-patient relationship, the burden falls on the physician to provide this knowledge to the patient as they are the medially trained entity. However, as shown in Figure 6, physicians on average over-estimated the time contributed to asthma education during offices visits when compared to patients.

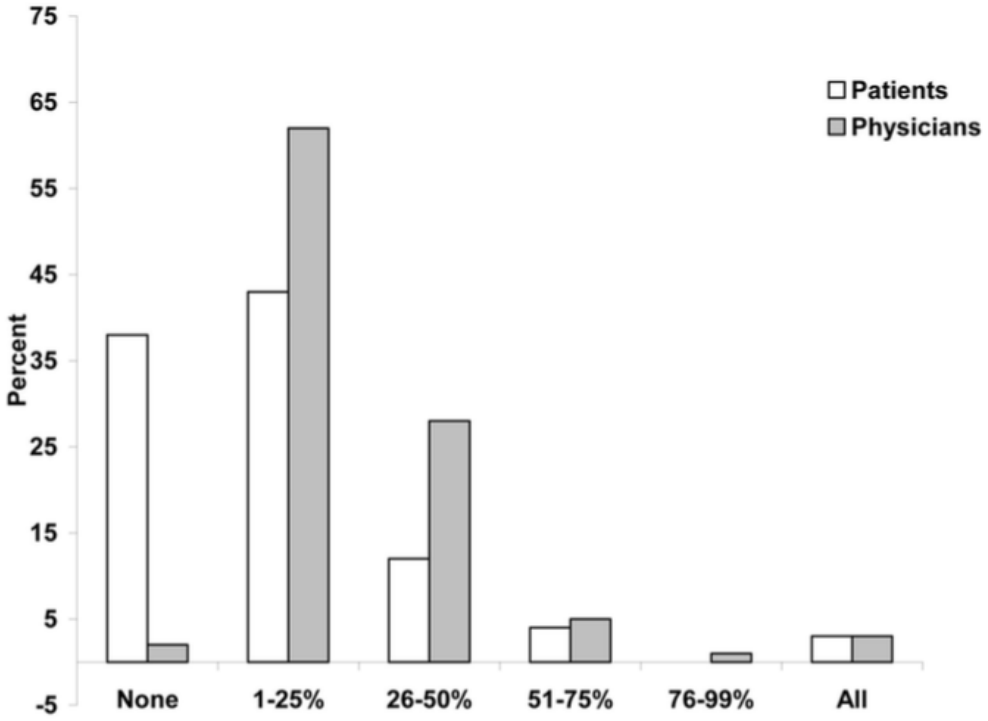

Figure 6. Percentage of office visit dedicated to asthma education as indicated by physicians and patients.[10]

Furthermore, similarly, when asked about the knowledge of inhaled corticosteroid side effects, physicians indicated a lower percentage of their patients as not knowing the associated side effects compared to a higher percentage of patients who self-indicated as not being aware (Table 2).

Table 2. Patient awareness of inhaled corticoid steroids side effects as indicated by physicians and patients[10]

	Patients		Physicians	
	Not Aware (%)*	Level of Concern*	Not Aware (%)†	Level of Concern†
Decreased cortisol production	46	3.9	14	4.4
Long-term side effects	39	5.1	6	5.1
Short-term side effects	19	4.6	5	5.7

Lastly, significant differences in the responses given by patients and physicians were also observed when asked about knowledge of potential health consequences as a result of medication noncompliance. As shown in Table 3, physicians indicated more of their patients were aware of the dangers associated with noncompliance than patients indicated as being aware of.

Table 3. Patient awareness of consequences of medication noncompliance as indicated by physicians and patients[10]

	Patients (%)*	Physicians (%)†
Increase symptoms	69	100
Limited physical activity	58	91
Increased use of bronchodilator	46	99
Nighttime awakenings	39	93
More frequent asthma attacks or asthma exacerbations	35	100
More severe asthma attacks	27	94
More physician visits	25	99
More hospitalizations or ER visits	13	90
Absence from work	10	87
Life-threatening asthma attacks	10	65
Less interaction with friends and family	9	55

The Global Initiative for Asthma Guidelines recommend that physicians and patients work as a team to ensure patient knowledge about a disease.[10,15] However, according to the results published in the GAPP survey, there are significant reported differences between the knowledge patients report having and physicians indicate they have given. Overall, these results suggest poor patient education in the US. Unsurprisingly, these discrepancies were not only observed between patients and physicians in the US. Based on the data exhibited in Table 4, significant reported differences between patients and physicians occurred globally.

Table 4. Comparison of US and Global GAPP survey results[10]

	Patients		Physicians	
	US	Global	US	Global
Perception of asthma education issues				
Mean percent of office visit devoted to asthma education	16%	25%	28%	35%
Physician's that believe that they always discuss long-term side effects with patient	n.a.	n.a.	25%	26%
Physician's that believe that they always discuss short-term side effects with patient	n.a.	n.a.	42%	59%
Patient's who feel that the physician always discusses long-term side effects with them	4%	8%	n.a.	n.a.
Patient's who feel that the physician always discusses short-term side effects with them	6%	10%	n.a.	n.a.
Patient perception of asthma disease control				
Patients reporting to have mild-to-moderate asthma	94%	89%	n.a.	n.a.
Percentage of patients with unscheduled office visits or reported to ED	26%	38%	n.a.	n.a.
Patients not receiving medical attention for asthma	21%	11%	n.a.	n.a.
Patients that did not know that exacerbations in mild patients could be fatal	40%	53%	n.a.	n.a.
Perception of ICS side effects				
Patients not aware of long-term side effects	39%	31%	6%	7%
Patients not aware of short-term side effects	19%	20%	5%	3%
Patients experienced long-term side effects	8%	19%	48%	48%
Patients experienced short-term side effects	36%	34%	92%	93%
Perception of therapy adherence				
Percentage of time that patients are always adherent to asthma treatment regimen	35%	48%	0%	0%
Patients experienced increased symptoms when they did not take asthma medication	69%	69%	100%	99%

The Effect of Racial and Socioeconomic Factors on Asthma Mortality

Marder et al. conducted an observational study in Chicago, Illinois using death certificates obtained from the Department of Public Health (DOPH). The parameters for inclusion into the study were individuals aged 5 to 34 whose underlying or contributing cause of death was related to asthma.[16] A total of 205 death certificates were used in the study and from which demographic information (i.e. age, sex, race, and socioeconomic status) was obtained.[16] African-Americans and non-Caucasian Hispanics accounted for 83% and 17% of death certificates used, respectively. Mortality rates for based on race and income were determined for the study population and then compared to that of Caucasian subjects in the similar geographical location and age range. Data pertaining to asthma mortality rates of Caucasian residents in Chicago were obtained from an initial study conducted by Weiss et al.[16,17] When asthma mortality rates were compared between African-Americans and Caucasians, it was found that across all age groups African-Americans had at least five times the mortality rate of Caucasians (Figure 7).

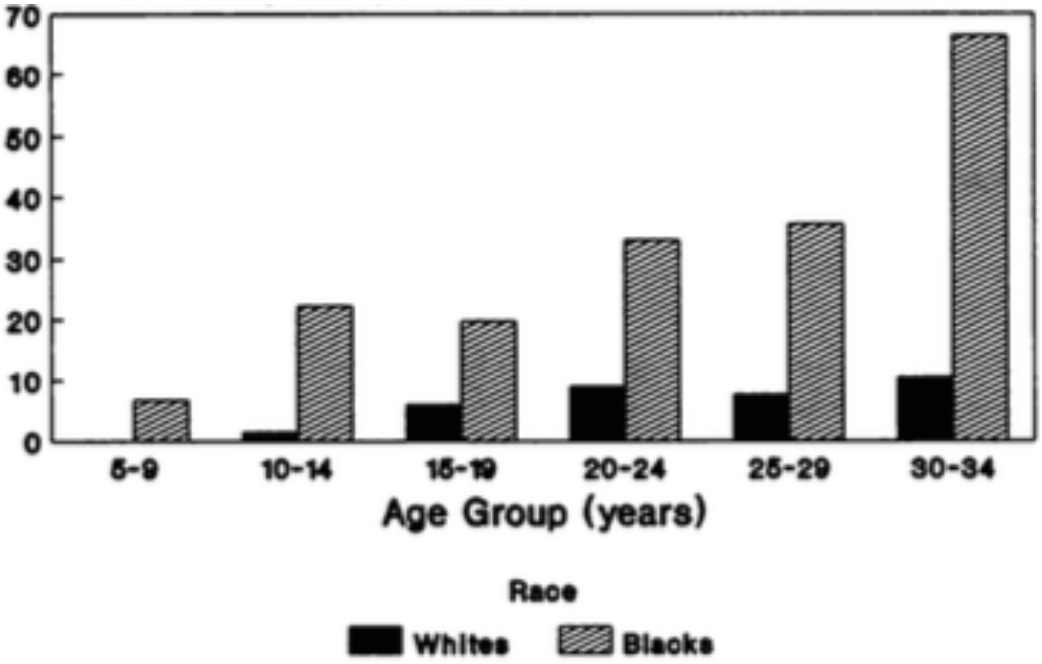

Figure 7. Asthma mortality rates by race and age group[16]

When taking a closer look at the areas in which the deaths occurred, it was found that asthma deaths disproportionately affected predominately black low socioeconomic neighborhoods on the south and west side of the city.[16] Asthma mortality rates for these areas were found to be higher than that of the general African-American population in Chicago.

Furthermore, this study also assessed asthma mortality rates by race and average household income. A significant ($p = 0.0001$) inverse relationship was observed between the mortality rate and average household income when Caucasians and African-Americans were combined and assessed across all SES groups.[16] However, when

African-Americans were examined separately, the inverse relationship, although present, was no longer significant (Figure 8).

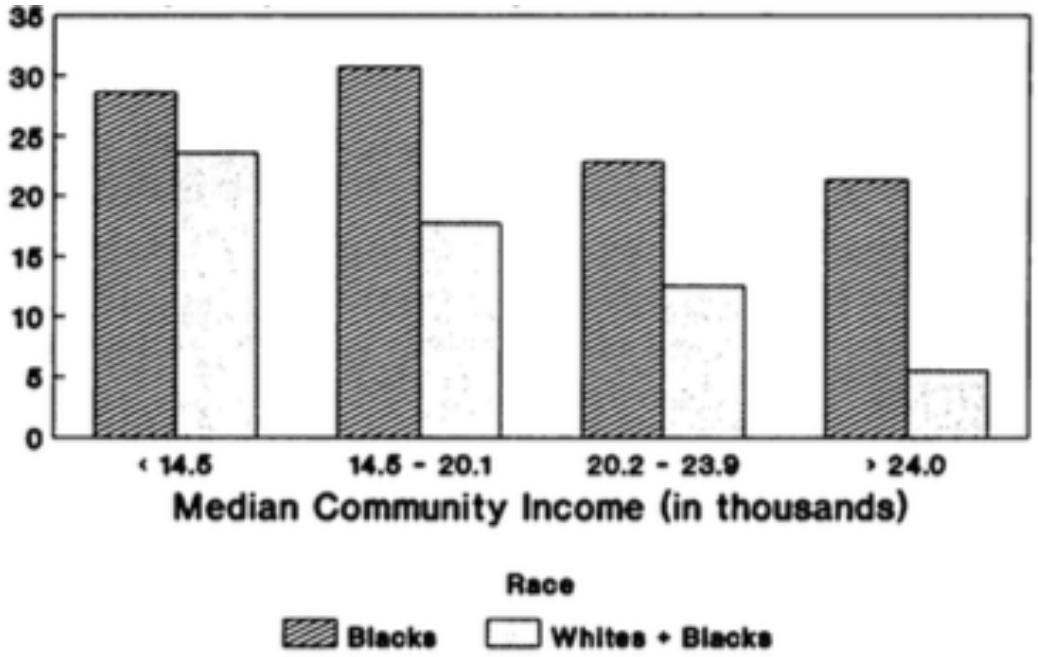

Figure 8. Asthma Mortality rates by race and SES[16]

Insurance and Quality of Care for Children with Acute Asthma

Ferris et. al. combined prospective data from 3 inception cohort studies from 36 emergency departments (ED) across 17 states on patients who had a physician diagnosis of asthma between the ages of 2 and 17 that presented to the ED with acute asthmatic symptoms.[18] Demographic information including asthma history, causes of exacerbation of asthma and types of insurance were collected on 1,184 participants who were enrolled into the study. Based on the chart review, four categories of insurance type were constructed and included managed care (prepaid plan, PPOs), indemnity (fee-for-service),

Medicaid, and uninsured.[18] The goal of this study was to assess whether a child's insurance status effects the quality and outcomes of care for their acute asthma.[18] Pre-ED and ED visits were used to indicate quality of care and measured through use of a questionnaire that inquired about 1) visiting a primary care physician prior to coming to the ED and 2) if the ED was site in which care and treatment for asthma was conducted, 3) use of an inhaled steroid, and 4) having a written at home asthma plan. Based on responses from participants and available hospital records, it was found that individuals with managed care and indemnity were more likely to visit their PCP the week prior to visiting an ED indicating access to better quality of care.[18]

Comparatively, children with Medicaid and those who were not insured ranked lower on the quality measurement performance scale than those with a form of privatized insurance.[18] Across the board uninsured children with asthma ranked the lowest in each quality measure. Furthermore, it was also found that Medicaid and uninsured participants were more likely visit an ED to seek care for acute asthma symptoms and less likely to have a designated PCP, when compared with managed care and indemnity participants.[18] As exhibited in table 5, individuals who had Medicaid or were uninsured on average had worst measures of quality care than those with privatized insurance.

Table 5. Quality measurements of care according to insurance status[18]

	Managed Care (n = 295)	Indemnity (n = 152)	Medicaid (n = 354)	Uninsured (n = 164)	*P* value
Pre-ED quality measures					
	97	97	90	79	<.001
Primary care provider status (%)	54	51	70	77	<.001
ED usual site for problem asthma care (%)	23	27	34	45	<.001
ED usual source of asthma prescriptions (%)					
Ratio >1 of ED visits to urgent clinic visits in past year (%)	41	45	53	58	.003
PCP visit in week prior to ED presentation (%)*	21	13	14	6	<.001
Inhaled corticosteroid during past 4 wk (%)	21	20	20	13	.15
Written home action plan (%)	37	38	35	27	.11
Summary quality score, median (IQR)	−1 (−2–1)	−1 (−2–1)	−1 (−2–1)	−1 (−2–0)	.24

Implications for Improving Medication Adherence

Horne et. al conducted an analysis on understanding the factors that influence patients to be non-adherent with asthma regimens. To adequately address noncompliance, it is essential to understand its underlying motives. Noncompliance can arguably be divided into two subcategories, intentional and unintentional non-adherance.[19] Horne et. al indicates intentional non-adherence occurs when a patient decides to take medications other than how prescribed, or discontinue use completely. This includes altering the dosage or frequency of use.[19] Unintentional non-adherence, on the other hand, occurs when external barriers prevent a patient from following the indicated regimen; including poor recall, comprehension, and physical inability.[19] Although, each type is clearly defined, noncompliant patients often have a mixture of influencer types.

Horne et. al carried out a study analyzing the perceived concerns and necessity of current asthma treatment among individuals with high and low adherence. As shown in Figure 9, the study found that individuals with low adherence to their asthma treatment had lower perceived necessity but higher concerns about their medication regimen than those with high adherence.[19] When the concerns of all study participants were further investigated, it was found that many things influenced their behavior of poor adherence; including meager patient education surrounding medication side effects and long-term effects (Figure 10). Horn et. al concluded that it is important to evaluate knowledge, motivation, and patient factors associated with adherence.[19]

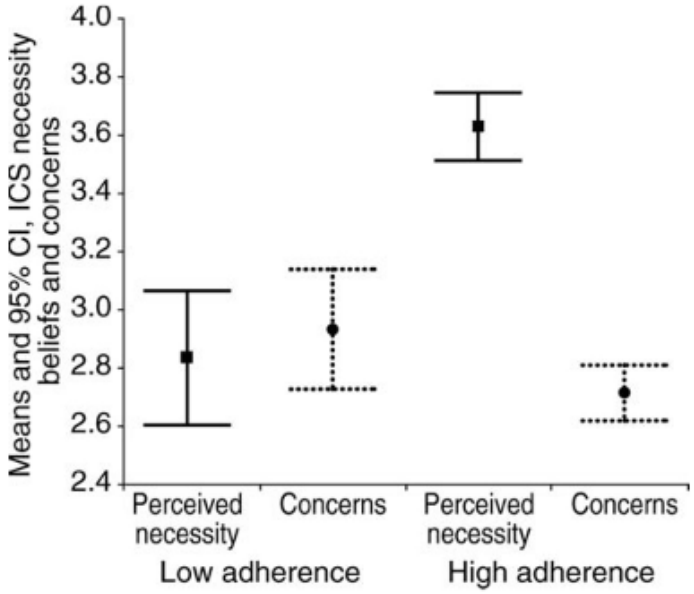

Figure 9. Perceived concerns and necessity of current asthma treatment among individuals with high and low adherence[19]

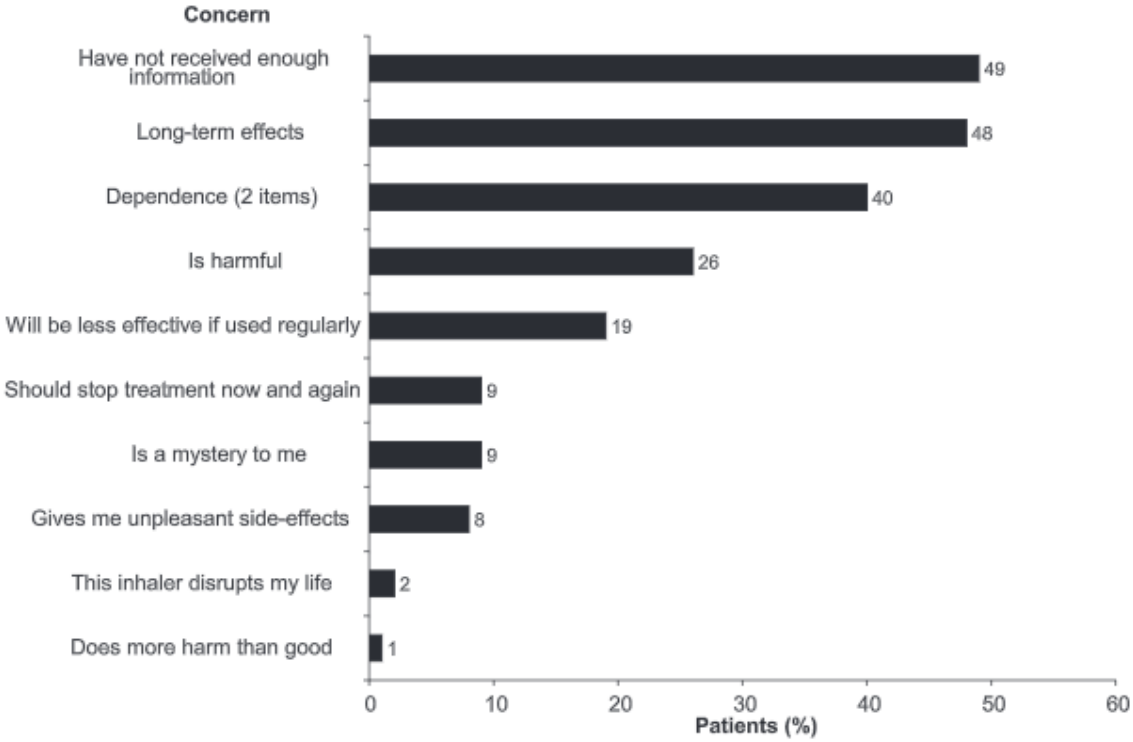

Figure 10. Profile of concerns regarding current asthma treatment[19]

Criterion for Successful Asthma Interventions

Clark et. al set out to compare and analyze various interventions targeted at reducing asthma prevalence and morbidity in the US. Various interventions assessed included those implemented in asthmatic children's homes targeted at dust mite reduction, within communities targeted at improving quality of care received, and out-reach programs geared towards improving patient asthma education.[20] Through observational and statistical analysis of these interventions, a model of influence of disease control was constructed, as well as, criteria for the successful implementation of interventions were revealed.

Clark et. al determined that in order for asthma to be effectively controlled, it requires attention and involvement from a wide range of stakeholders.[20] As depicted in Figure 11, the patient, family, clinicians, work/school support, community, environment, and policy all contribute to disease maintenance in varying degrees; the closer the rings are to the center, indicates a greater impact.[20] Family has the biggest impact on disease control, especially if the afflicted individual is a child, since extensive physical and emotional support is required. Next, are clinicians, whom are expected to provide medical services and guidance for the patient and family to control the disease.[20] Moving towards the outer rings of the diagram, it can be seen that work/school, communities, environmental controls, and even legislation in the form of policy can have an impact on the maintenance of asthma.

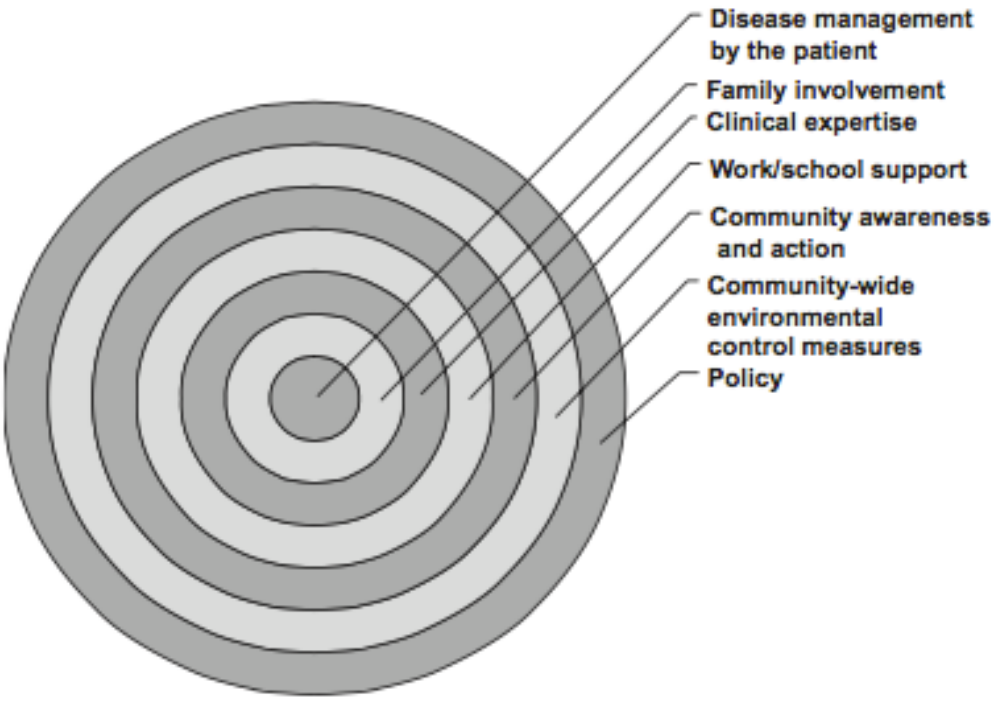

Figure 11. Factors that influence Disease management.[20]

Many of the interventions explored in this study had areas of success pertaining to asthma control in their respective areas; thus, based on their achievements, the goals and characteristics of these organizations were compared to determine if common features were evident amongst them. It was found that successful interventions recognized multiple factors that influence asthma and its control, carefully assessed individual risk factors and needs towards achieving asthma control, specifically tailoring program elements to the individual, basing interventions on realistic principles, and considering both the physical and social environment.[20]

DISCUSSION

Often times in medicine when a treatment is developed, it is designed to be effective for the majority of the population. Usually this feat poses little issue for communicable diseases, as there is commonly a single source for illness. For non-communicable diseases like asthma, the cause and effect analysis necessary for the development of treatments is cumbersome and multivariable. The source of origin for asthma is unknown however, through vigorous research effective treatments such as Beta-agonists and combination therapies. Unlike therapies designed for communicable diseases, these treatments do not "cure" the disease; rather they treat the symptoms associated with asthmatic episodes. These vital medicines have led to the general decrease in asthma associated mortality rates. However, when studies such as those conducted by Blaiss et. al, Marder et. al, Horne et. al and Ferris et al take a closer look at the distribution of asthma amongst US citizens, their results showed increased asthma rates within subsets of the population.

Chronic disorders typically place substantial burden on health care systems. As indicated by Lozano et. al, individuals with asthma tend to rely on the health system more than those without asthma and incur at least twice as much health expenditure as a result. Thus, knowing what causes high risk population to have uncontrolled asthma interventions could be improved. A managed chronic disease would not only reduce the burden on the health system but also on low socioeconomic communities suffering from

asthma. A key way to manage chronic diseases is through medication compliance. As indicated by Horne et. al, medication noncompliance cost the US health system approximately $100 billion a year from expired and unused dispensed medicines;[19] thus, understanding the causes of non-adherence can reduce the financial burden and mortality rates of chronic ailments.

Blaiss et. al study results highlights an important issue within the US health system among patients and physicians. It emphasizes the perspectival difference between physicians and their asthmatic patients, where physicians believe their patients are more knowledgeable about their diagnosis than what is reported by patients. The lack of continuity between physicians and patients suggests poor patient education in healthcare settings. Furthermore, Horne et. al indicated in his study that concerns regarding asthma treatment for non-adherent asthmatics mainly stems from a lack of basic information, the likelihood of becoming dependent, and potential side effects of their asthma medication. Therefore, improving patient education by tailoring it to address the specific concerns of patients could improve asthma maintenance in high-risk populations.

In alignment with other countries in both the developed and developing worlds, the poor and disenfranchised bear the brunt of asthma disparities within the United States. As found by Marder et. al, when comparing African-Americans and Caucasians in Chicago African-Americans were found to have a substantially higher rate of asthma mortality than Caucasians. Furthermore, when socioeconomic status was also evaluated,

poor African-Americans were found to have the highest rates of mortality than wealthier individuals of both black and white decent. These results indicated that although urbanized areas often have higher asthma prevalence, specific ethnic populations are likely to be more impacted than others, as well as specific socioeconomic groups.

As noted by Ferris et. al a difference in quality of care received for asthma treatment was observed for individuals who had different insurers. Specifically, it was found that individuals who had Medicaid or were uninsured on average had worse measures of quality care than those with privatized insurance. Typically, individuals of low socioeconomic status are more likely to rely on government programs, like Medicaid, for additional assistance. Therefore, it can also be concluded that in addition to ethnicity and SES status, types of insurance can also impact asthma management. Lastly, Blaiss et. al also indicated patient education as an additional influence on asthma management, by showing the disparity in responses given by patients and physicians regarding their knowledge about asthma. Despite the responsibility placed on physicians to provide education and treatment of a disease, many patients reported not knowing the side effects of asthma medications or the consequences of non-adherence to treatment. Thus, when asthma is poorly managed, it will cause preventable increases in DALYs, premature deaths, and health care expenditure for both the individual and the system.

In addition to research conducted on environmental pathogens, disparities in socioeconomic status, patient education, and medical insurance can be taken into account

when designing effective asthma interventions, especially within high-risk areas. As indicated by Clark et. al successful interventions usually recognize multiple factors that influence asthma and its control, carefully assess individual risk factors and needs towards achieving asthma control, and specifically tailor program elements to the individual. In closing, since many interventions are geared towards the reduction of environmental pathogens associated with the exacerbation of asthma, it is hoped that with the evidence and recommendations provided within this analysis, interventions will be reformed in the future.

CONCLUSION

As shown in this analysis, asthma maintenance is influenced by many factors including those not generally acknowledged in many interventions and treatment approaches. As shown, there is a specific demographic population in which asthma prevalence and mortality rate is unusually high. Furthermore, the association of this high-risk population with lack of patient education, low socioeconomic status, and Medicaid, indicates the influence of these factors. By improving current asthma interventions and remodeling them to take a broader stance by also acknowledging the presence of these disparities, asthma will likely be better controlled for all individuals in the US. Ultimately, if success is achieved with the newly innovated interventions, they may be used in other countries who are experiencing comparable difficulties with asthma maintenance.

REFERENCES

1. WHO | Asthma. (2013). http://www.who.int/mediacentre/factsheets/fs307/en/

2. National Heart, Lung, and Blood Institute (2014). What Is Asthma? *NHLBI, NIH.* http://www.nhlbi.nih.gov/health/health-topics/topics/asthma

3. D'Amato, G., Liccardi, G., D'Amato, M., & Holgate, S. (2005). Environmental risk factors and allergic bronchial asthma. *Clinical & Experimental Allergy*, *35*(9), 1113–1124. http://doi.org/10.1111/j.1365-2222.2005.02328.x

4. Gern, J. E. (2010). The Urban Environment and Childhood Asthma Study. *Journal of Allergy and Clinical Immunology*, *125*(3), 545–549. http://doi.org/10.1016/j.jaci.2010.01.037

5. Mescher, A. L. (2013). Chapter 17. The Respiratory System. In *Junqueira's Basic Histology, 13e* (Vols. 1–Book, 1–Section). New York, NY: The McGraw-Hill Companies. Retrieved from http://mhmedical.com/content.aspx?aid=57332868

6. Milligan, K. L., Matsui, E., & Sharma, H. (2016). Asthma in Urban Children: Epidemiology, Environmental Risk Factors, and the Public Health Domain. *Current Allergy and Asthma Reports*, *16*(4), 1–10. http://doi.org/10.1007/s11882-016-0609-6

7. Gern, J. E., Visness, C. M., Gergen, P. J., Wood, R. A., Bloomberg, G. R., O'Connor, G. T., Busse, W. W. (2009). The Urban Environment and Childhood Asthma (URECA) birth cohort study: design, methods, and study population. *BMC Pulmonary Medicine*, *9*, 17. https://doi.org/10.1186/1471-2466-9-17

8. Masoli, M., Fabian, D., Holt, S., Beasley, R., & Global Initiative for Asthma (GINA) Program. (2004). The global burden of asthma: executive summary of the GINA Dissemination Committee Report. *Allergy*, *59*(5), 469–478. https://doi.org/10.1111/j.1398-9995.2004.00526.x

9. Akinbami, L., Moorman, J., Bailey, C., Zahran, H., King, M., Johnson, C., and Liu, X. (2012). Trends in Asthma Prevalence, Health Care Use, and Mortality in the United States, 2001 -2010. *Center for Disease Control*. NCHS data brief, no 94. Hyattsville, MD: National Center for Health Statistics

10. Blaiss, M. S., Kaliner, M. A., Baena-Cagnani, C. E., Dahl, R., Valovirta, E. J., & Canonica, G. W. (2009). Barriers to Asthma Treatment in the United States: Results from the Global Asthma Physician and Patient Survey: *World Allergy Organization Journal*, *2*(12), 303–313. http://doi.org/10.1097/WOX.0b013e3181c81ea4

11. Higgins, C. J. (2003) The Crashing Asthmatic. *American Family Physician*. 67(5):997-1004. http://www.aafp.org/afp/2003/0301/p997.html#sec-6

12. Baldwin, W., and Amato, L., (2012) Fact Sheet: Global Burden of Noncommunicable Diseases. http://www.prb.org/Publications/Datasheets/2012/world-population-data-sheet/fact-sheet-ncds.aspx

13. Crosta, P. (2013). Asthma History - Through the Ages. *Medical News Today*. http://www.medicalnewstoday.com/info/asthma/asthma-history.php

14. Gergen, P. J., & Togias, A. (2016). Inner City Asthma. *Immunology and Allergy Clinics of North America*, *35*(1), 101–114. https://doi.org/10.1016/j.iac.2014.09.006

15. GINA: the global initiative for asthma. (2016). *GINA*. http://ginasthma.org/2016-pocket-guide-for-asthma-management-and-prevention/

16. Marder, D., Targonsi. P., Orris. P., Persky. V., and Addington. W. (1992) Effect of Racial and Socioeconomic Factors on Asthma Mortality in Chicago. *Science Direct*. 1(6), 426-429. http://dx.doi.org/10.1378/chest.101.6_Supplement.426S

17. Weiss, K.B., Wagner, D.K. (1990). Changing patterns of Asthma Mortality: identifying target populations at high risk. *JAMA: Journal of the American Med. Assn*. 264:1683-87

18. Ferris, T. G., Crain, E. F., Oken, E., Wang, L., Clark, S., & Camargo Jr, C. A. (2001). Insurance and Quality of Care for Children with Acute Asthma. *Ambulatory Pediatrics*, *1*(5), 267–274. https://doi.org/10.1367/15394409(2001)001<0267:IAQOCF>2.0.CO

19. Horne, R., & Weinman, J. (2002). Self-regulation and Self-management in Asthma: Exploring the Role of Illness Perceptions and Treatment Beliefs in Explaining Non-adherence to Preventer Medication. *Psychology & Health*, *17*(1), 17–32. https://doi.org/10.1080/08870440290001502

20. Clark, N. M., Mitchell, H. E., & Rand, C. S. (2009). Effectiveness of Educational and Behavioral Asthma Interventions. *Pediatrics*, *123*(Supplement 3), S185–S192. https://doi.org/10.1542/peds.2008-2233I

CURRICULUM VITAE